

Comment prévenir les complications thrombo-emboliques au cours d'une chirurgie endovasculaire de la crosse ?

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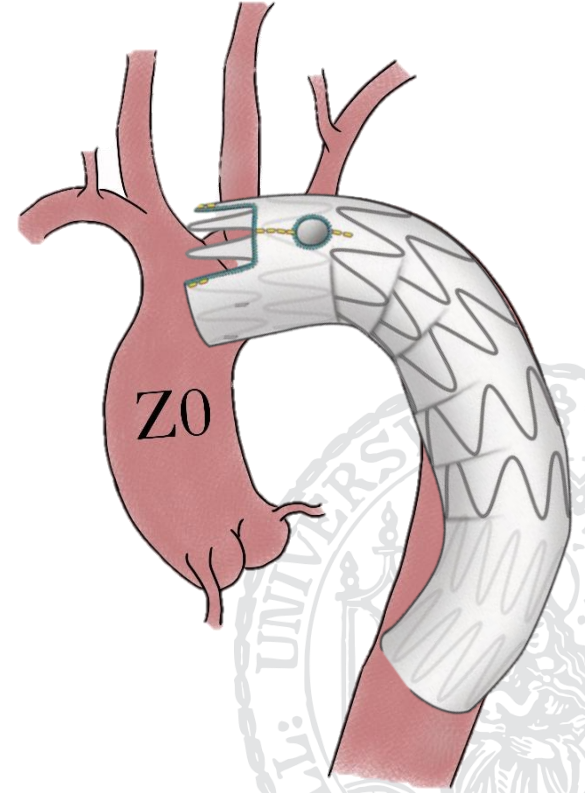
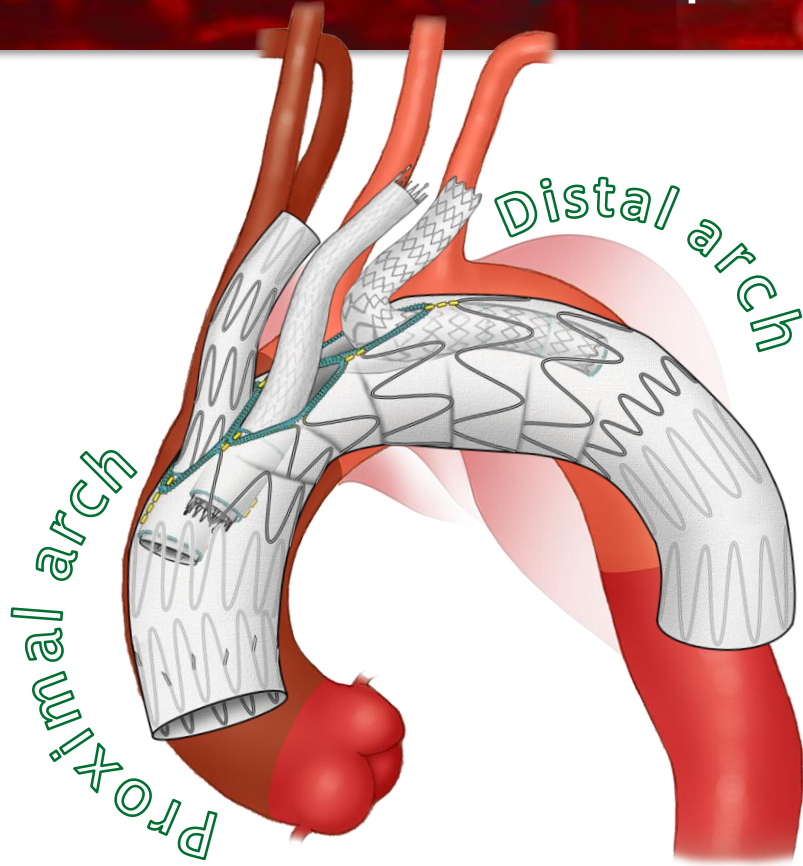
Conflict of Interest



None



Endovascular Aortic Arch Repair



Available Multi-Branched Arch Endografts

Custom-made Solutions

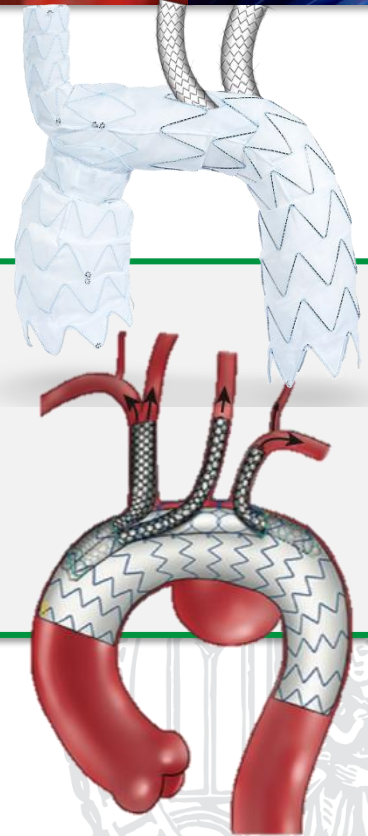


Cook Zenith Arch Endograft

Terumo Relay® Branch

Artivion NEXUS® Aortic Arch

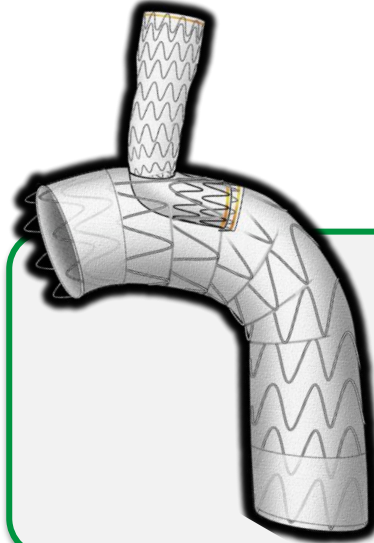
Lifetech Concave Stent Graft



Available Single-Branched Arch Endografts

Approved for Z0 landing

Off-the-Shelf Solutions



Off-the-Shelf
Gore TBE[®]
Artivion NEXUS[®]



Require cervical debranching
OR
Other “off-label” additional procedures

Patient Selection

- Elderly fragile patients unfit for open repair
- High-perioperative surgical risk / Multimorbid patients
- Previous sternotomies



Stroke remains the Achilles' heel of endovascular aortic arch repair



Stroke rate in fenestrated/branched Arch procedures

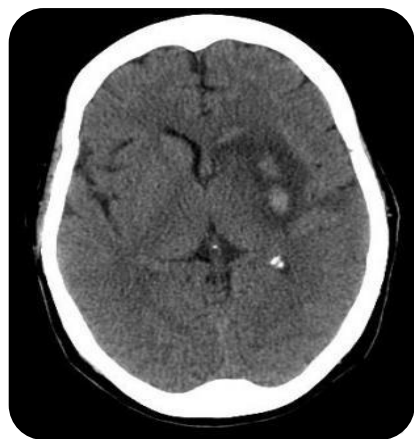
SYSTEMATIC REVIEW

Outcomes of Fenestrated and Branched Endografts for Partial and Total Endovascular Repair of the Aortic Arch — A Systematic Review and Meta-Analysis

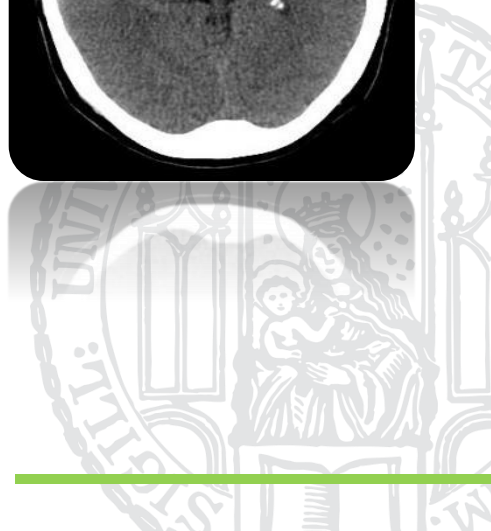
Paolo Spath ^{a,b,*}, Federica Campana ^a, Nikolaos Tsilimparis ^c, Enrico Gallitto ^{a,d}, Rodolfo Pini ^{a,d}, Gianluca Faggioli ^{a,d}, Stefania Caputo ^a, Mauro Gargiulo ^{a,d}

^aVascular Surgery, University of Bologna, DIMEC, Bologna, Italy
^bDepartment of Vascular Surgery, Hospital "Infermi" Rimini, AUSL Romagna, Rimini, Italy
^cDepartment of Vascular Surgery, Ludwig-Maximilian University Hospital, Munich, Germany
^dBologna Metropolitan Vascular Surgery Unit, IRCCS Azienda Ospedaliero-Universitaria S. Orsola, Bologna, Italy

Outcome	Studies - n	Patients - n	Events - n	Pooled outcome rate - %	95% CI	I ² - %	p Het	p value F vs. B
<i>Major or disabling stroke</i>								
Overall	13	447	22	6.2	0.04-0.09	0	.63	.54
Fenestrated endograft	4	167	7	5.3	0.03-0.10	0	.76	
Branched endograft	9	280	15	6.8	0.04-0.11	3.1	.41	
<i>Spinal cord ischaemia</i>								
Overall	15	540	15	4.5	0.03-0.07	0	.76	.83
Fenestrated endograft	4	197	7	3.9	0.02-0.08	0	.95	
Branched endograft	9	280	6	4.3	0.02-0.08	0	.79	



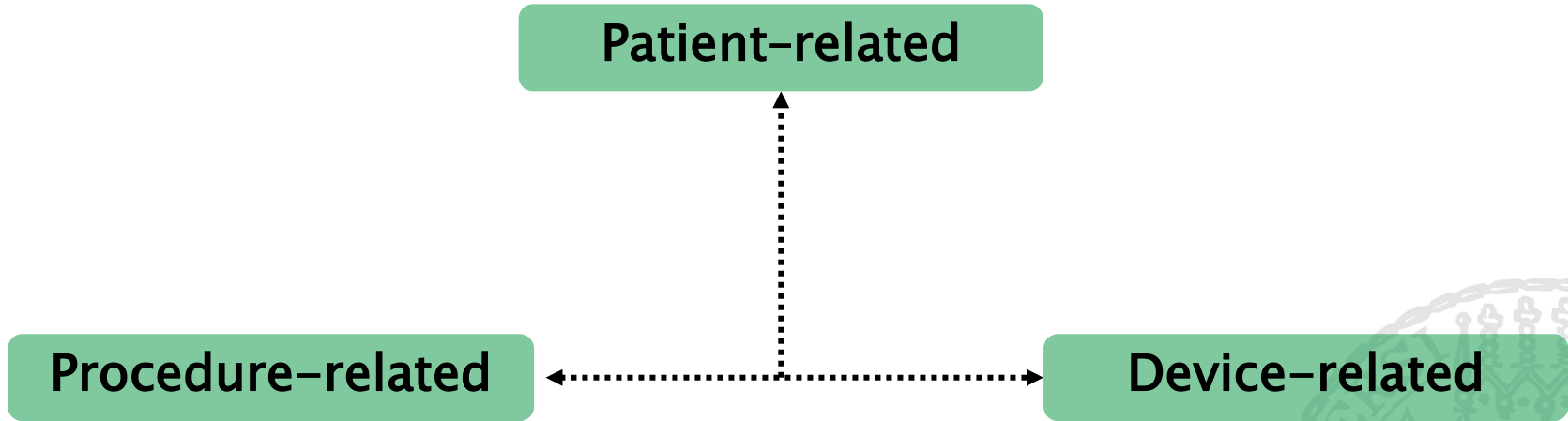
Major Stroke: 6.2%
SCI: 4.5%



If we want to prevent these complications, we first need to understand why they happen.



Stroke is Multifactorial!







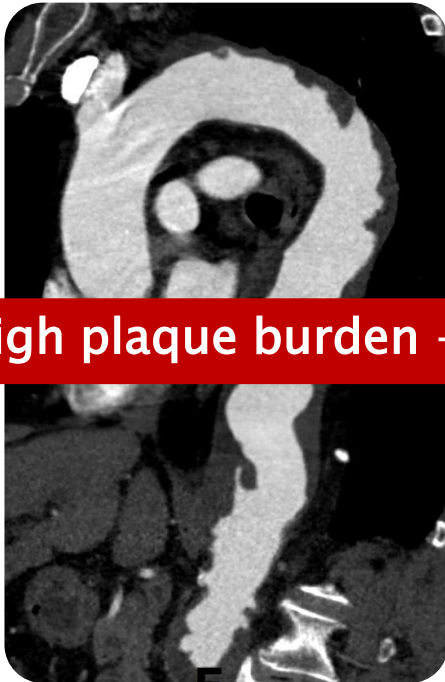
Incidence and Prognostic Associations of Early Postoperative Stroke and Death Among Patients Undergoing Inner Branched Thoracic Endovascular Repair of Aortic Arch Pathologies: A Systematic Review and Meta-Analysis

Jiang-Ping Gao, PhD, MD¹ , Wei Guo, PhD, MD² ,
 and Hong-Peng Zhang, PhD, MD²

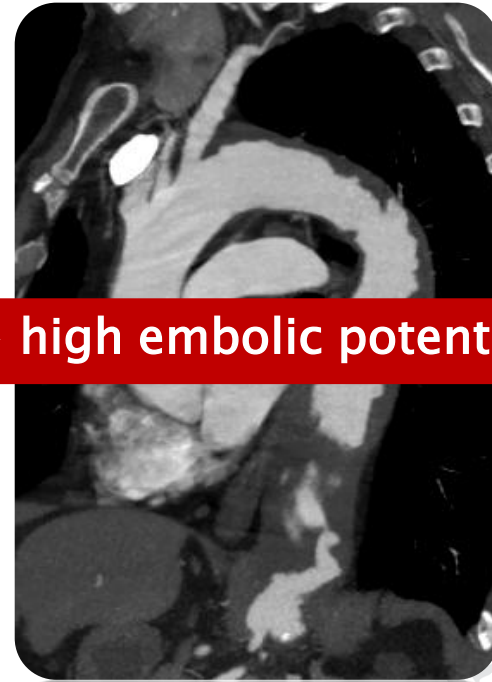
12 studies & 289 participants
 30-day postoperative stroke was 10.6%
 Combined early stroke/death was 15.7%

Factor	Values of factor	Incidence	95% CI		Q	p-value	OR	95% CI	
			Lower	Upper				Lower	Upper
Incidence of 30-days postoperative stroke									
Age	<71.3 years	0.0828	0.0444	0.1211	6.69	0.0097	2.763	1.369	5.579
	≥71.3 years	0.2041	0.1206	0.2877					
COPD%	<30%	0.0756	0.0346	0.1167	6.51	0.0107	2.650	1.289	5.451
	≥30%	0.1768	0.1108	0.2428					
non-AD%	<60.8%	0.0756	0.0346	0.1167	6.51	0.0107	2.650	1.289	5.451
	≥60.8%	0.1768	0.1108	0.2428					
Brand	Cook	0.0828	0.0444	0.1211	6.71	0.0349	2.756 ^a	1.336	5.684
	Bolton ^b	0.2022	0.1144	0.2901					
	Gore	0.2222	0.0000	0.4938					

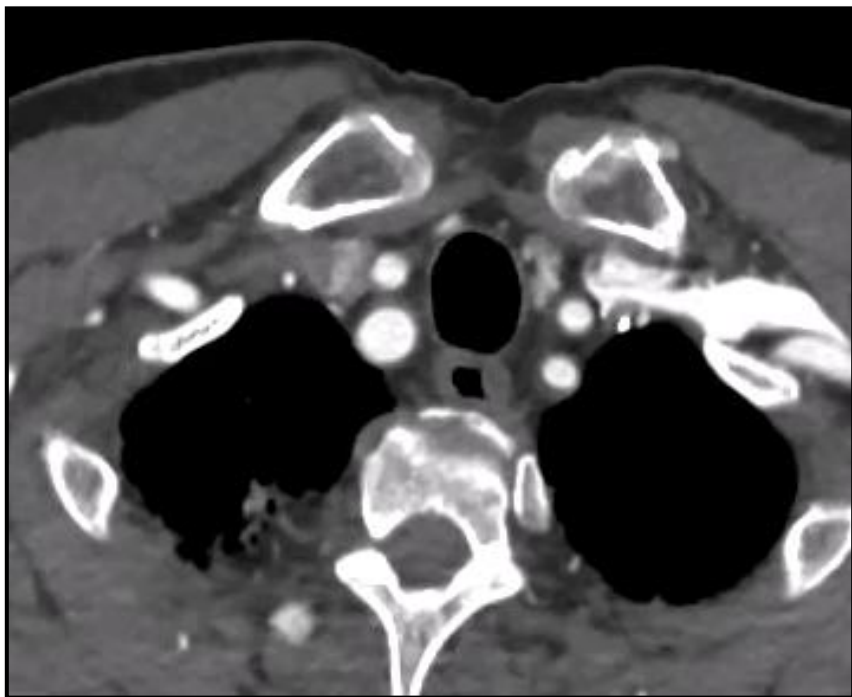
Shaggy Aortic Arch



High plaque burden + ulceration → high embolic potential



Patient selection! Consider rejecting shaggy arches!



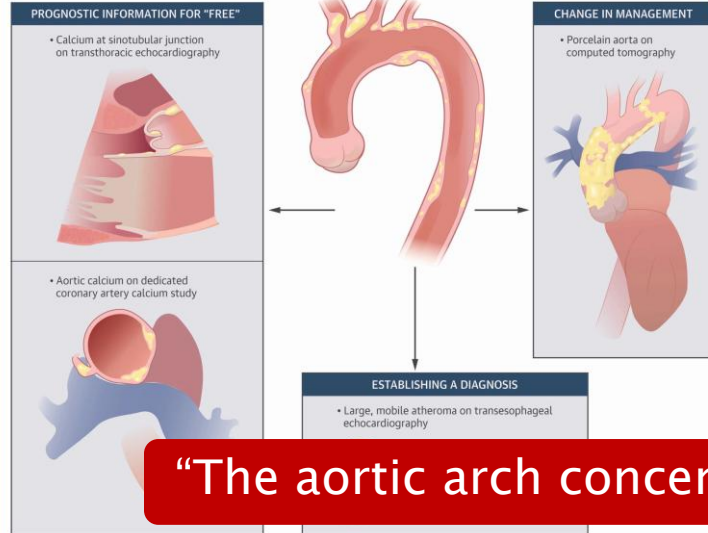
- Postoperative stroke
- Hemiparesis of the right arm, aphasia, swallowing disorder

Calcified Aortic Arch



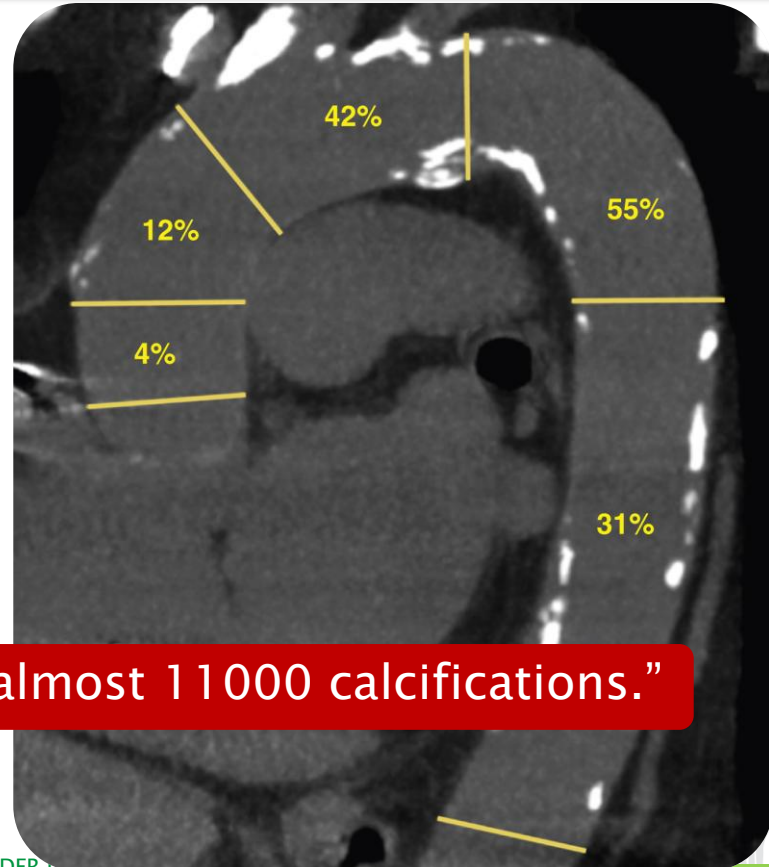
CENTRAL ILLUSTRATION: The Value of Imaging Thoracic Aortic Calcifications

IMAGING THORACIC AORTIC CALCIFICATIONS



Desai, M.Y. et al. J Am Coll Cardiol Img. 2018;11(7):1012-26.

“The aortic arch concentrates 60% of almost 11 000 calcifications.”






Native Ascending Aortic PLZ

vs

Non- Native Ascending Aortic PLZ



Proximal Landing Zone's Impact on Outcomes of Branched and Fenestrated Aortic Arch Repair

Petroula Nana ^{*} , Konstantinos Spanos ¹ , Giuseppe Panuccio, José I. Torrealba, Fiona Rohlffs, Christian Detter, Yskert von Kodolitsch and Tilo Kölbel ¹ 



Variable (N, %)	nNPAL Group (83 Patients)	NPAL Group (126 Patients)	p
Technical success	82 (98.8)	119 (94.4)	0.07
Mortality	5 (6.0)	15 (11.9)	0.16
Stroke	4 (4.8)	17 (13.5)	0.04
- Major stroke	2 (2.4)	10 (7.9)	0.09
- Minor stroke	2 (2.4)	7 (5.5)	0.27
Spinal cord ischemia	3 (3.6)	7 (5.5)	0.52
- Grade 1	0 (0.0)	3 (2.4)	0.36
- Grade 2	3 (3.6)	3 (2.4)	0.60
- Grade 3	0 (0.0)	1 (0.8)	0.77
- Complete recovery	1 (1.2)	4 (3.2)	0.36
- Late evolution	0 (0.0)	1 (0.8)	0.77
- Cerebrospinal fluid drainage	9 (10.4)	28 (22.2)	0.03
Retrograde type A dissection	NA	5 (3.9)	-
Congestive heart failure	2 (2.4)	5 (3.9)	0.54
Pericardial effusion	2 (2.4)	7 (5.5)	0.27
Acute kidney injury	12 (14.4)	7 (5.5)	0.03
- Access-related reinterventions	14 (16.9)	16 (12.7)	0.40
Myocardial infarction	0 (0.0)	3 (2.4)	0.36
Respiratory failure	4 (4.8)	9 (7.1)	0.49
Endoleak at pre-discharge CTA			
Type I	27 (32.5)	14 (11.1)	<0.001
- Type Ia	14 (16.9)	8 (6.3)	0.02
- Type Ib	10 (12.0)	5 (3.9)	0.03
- Type Ic	3 (3.6)	1 (0.8)	0.06
Type II	4 (4.8)	6 (4.8)	0.98
Type III	4 (4.8)	9 (7.1)	0.49

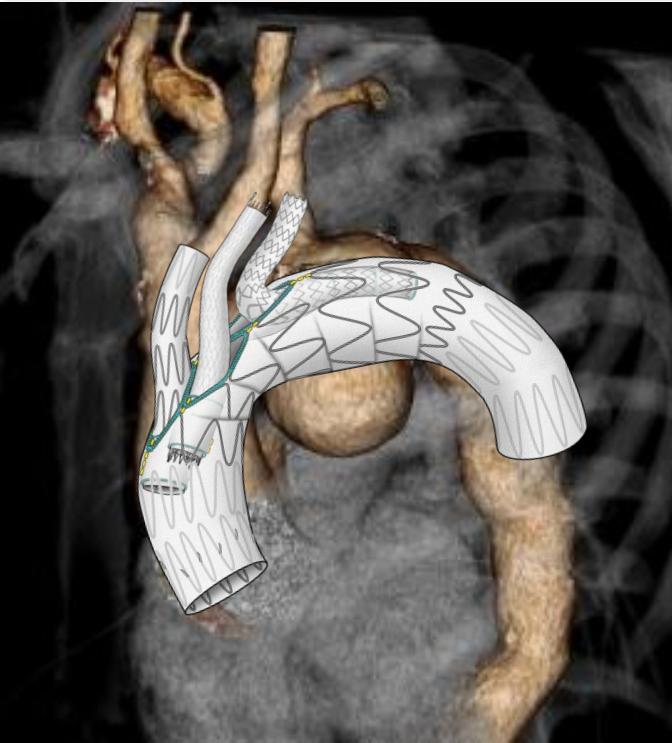
nNPAL as an independent protector for stroke ($p = 0.002$)

This does not mean graft landing is risk-free...

Suboptimal proximal anastomosis after open repair



...but the procedure is what triggers embolization!



Block-Ans



Reduce Arch manipulation!

- M, 82 y/o
- Chronic type A dissection
- Medical history:
 - Bentall with mechanical valve
 - Bladder cancer



Procedure

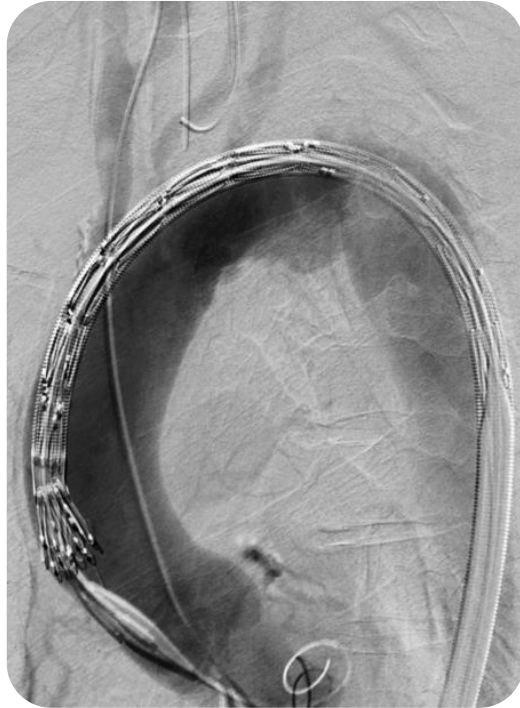
- Innominate artery:
Deployment of bridging stent





Stroke!

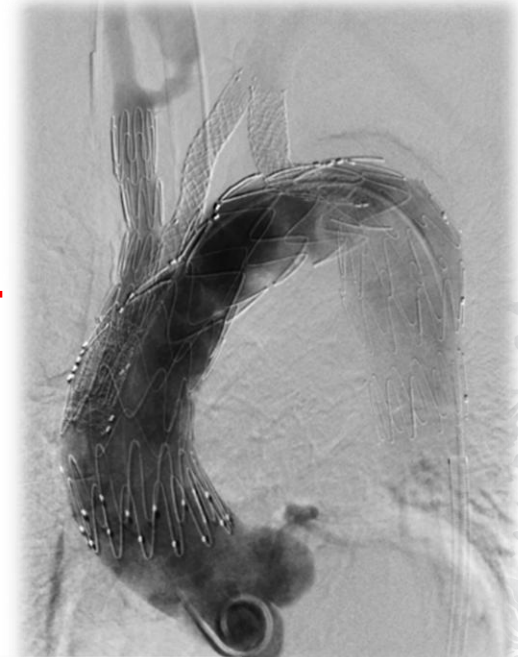
Avoid carotid manipulation!



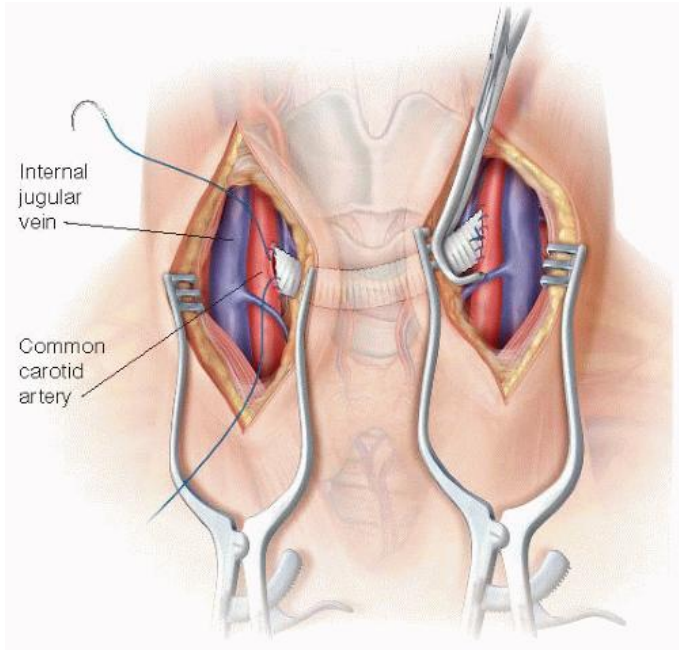
IA: Thoracic CMD Extension
13-16-90 + BeGraft+ 10x58

LCCA: VBX 8x58 + Viabahn 8x50

LSA: BeGraft+ 10x58



Stroke!



- ❖ Increased risk of cervical hematomas
- ❖ Increased risk of nerve injuries
- ❖ Delayed extubation
- ❖ Repeated supra-aortic clamping





- 80 patients
- Percutaneous femoral and axillary access in 77 cases
- In 3 cases cut-down for RCCA access
- Technical success was 100%
- 30-day results: No death nor cerebrovascular event





Transaxillary Branch-to-Branch-to-Branch Carotid Catheterization Technique for Triple-Branched Arch Repair

Journal of Endovascular Therapy

1-9

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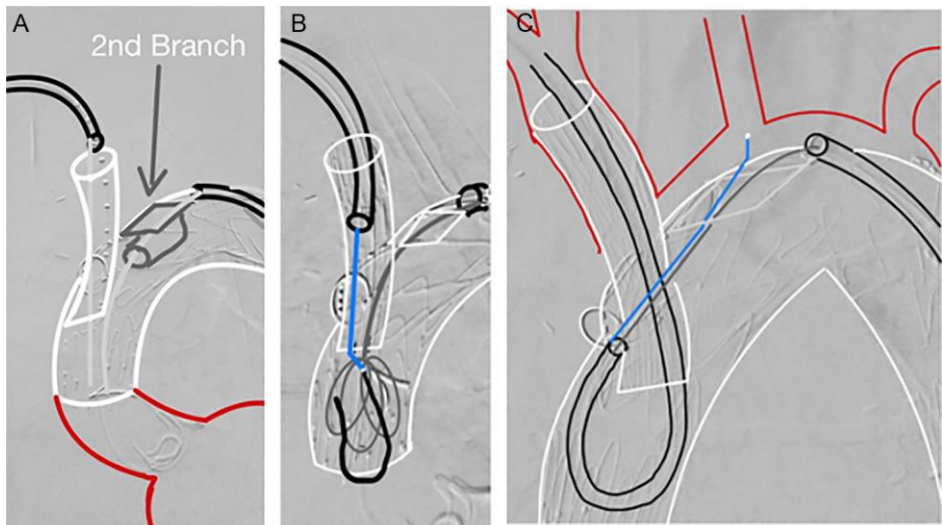
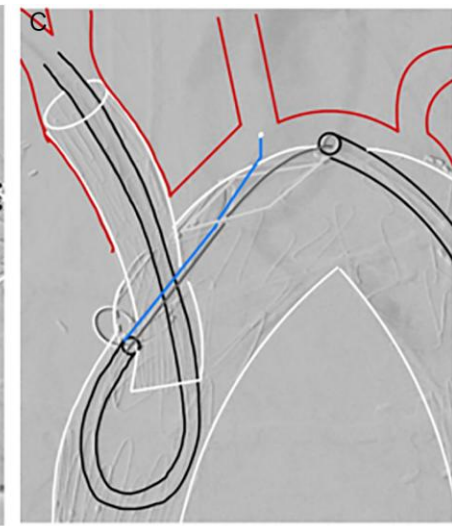
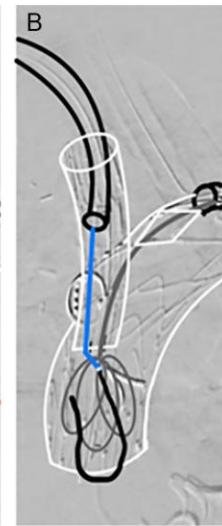
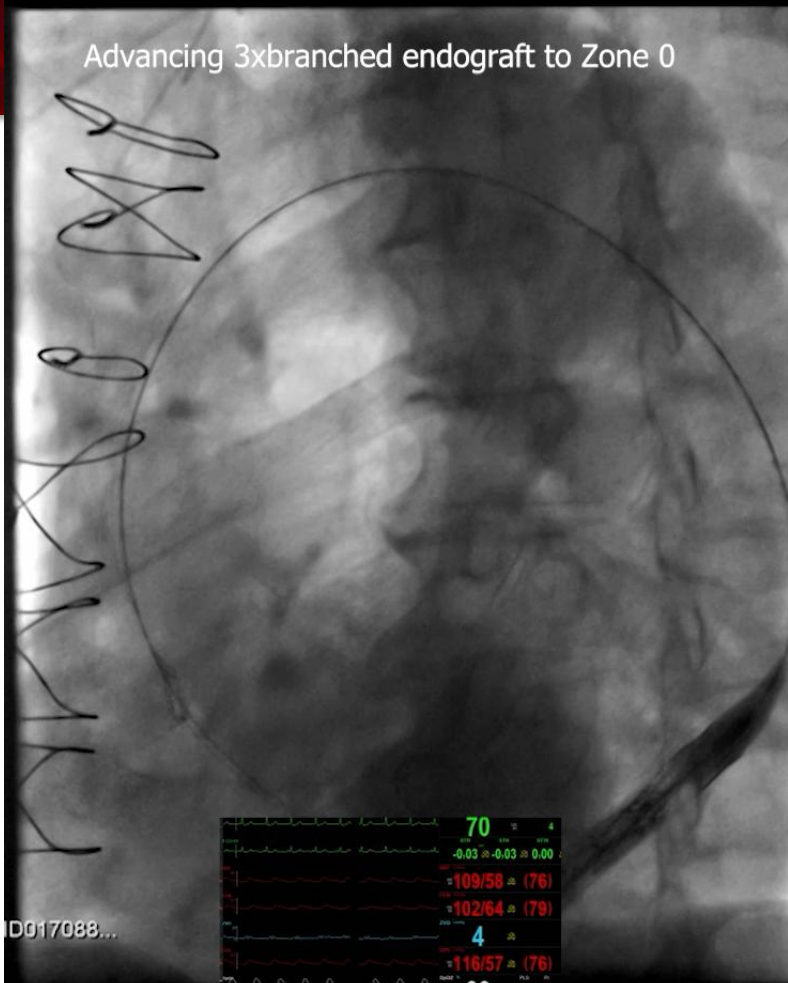


Table 1. Demographic characteristics and procedural data of the seven cases performed with the transaxillary 3BRA-CCE technique.

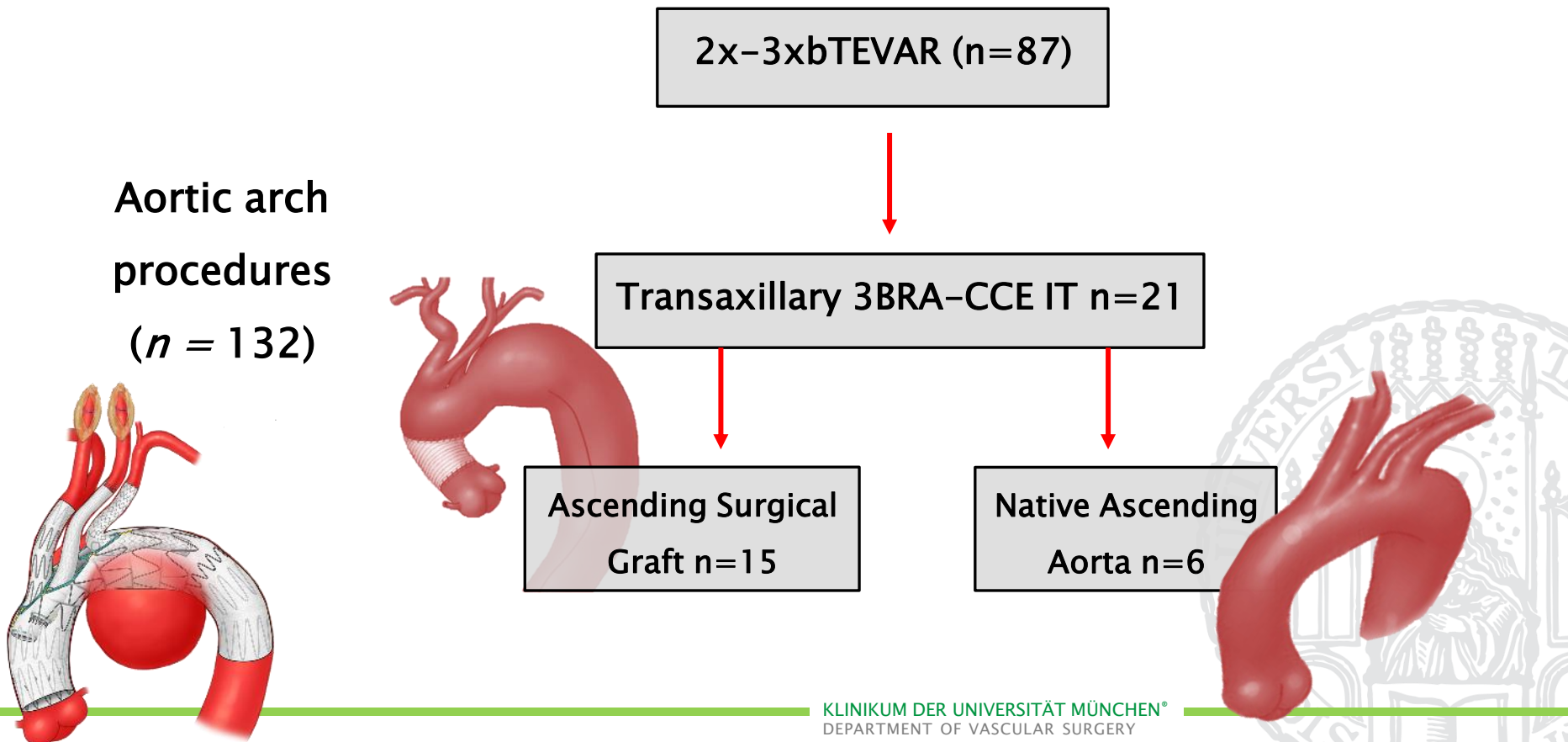
Case #	Age, sex	Pathology	Repair/ concomitant procedures	Total OP time (hours)	Discharge (postoperative day)	30-Day mortality	30-Day stroke	Reinterventions	FU time (months)
1	61 years, male	Post-TAAD 65-mm aortic arch aneurysm	3× bTEVAR + distal extension + candy plug + coiling of the false lumen	5:49	8	No	No	No	11
2	64 years, male	Post-TAAD 57-mm aortic arch aneurysm	3× bTEVAR + distal extension	4:23	6	No	No	Yes, relining of the left common carotid artery stent due to small dimension, 4 months PO	7
3	85 years, male	Ruptured 37-mm aortic arch PAU	3× bTEVAR	3:12	35	No	No	Thoracic tube, VATS	7
4	68 years, male	Post-TAAD 60-mm aortic arch aneurysm and 72-mm thoracic aneurysm	3× bTEVAR + distal extension	5:00	16	No	Delirium, microemboli in control MRT	No	7
5	78 years, male	Post-TAAD 62-mm aortic arch and thoracic descending aneurysm	3× bTEVAR + distal extension	5:32	10	No	No	No	5
6	73 years, male	PAU of the ascending aorta	3× bTEVAR	3:42	22	No	No	No	3
7	84 years, male	Symptomatic aortic arch aneurysm with a max. diameter of 65 mm	3× bTEVAR + distal extension	4:15	21	No	No	No	1

- 2022-2025 – 17 patients
 - Axillo- femoral
 - through-and-through wire

Advancing 3xbranched endograft to Zone 0

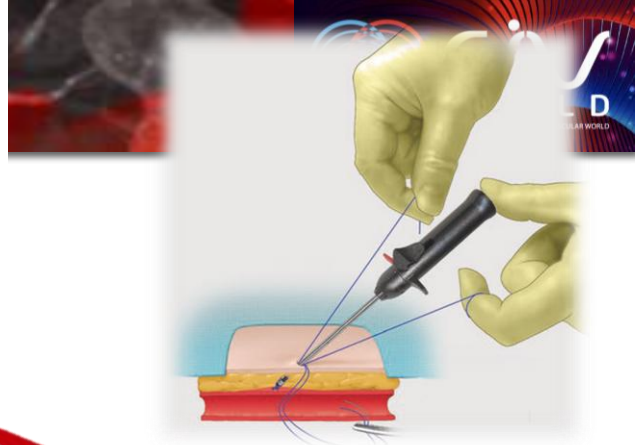


How we do it in Munich? LMU Experience Sep. 2018 – Jan. 2026



Carotid artery percutaneous access with vessel closure devices in endovascular aortic arch repairs

Alessandro Grandi, MD,^a Nuno V. Dias, MD,^b Stephan Haulon, MD,^c Timothy Resch, MD,^{d,e} Gustavo S. Oderich, MD,^f Michele Piazza, MD,^g Giovanni Pratesi, MD,^h and Luca Bertoglio, MD,^a on behalf of the CARPA Investigators, *Brescia, Padova, Genoa and Italy; Malmö, Sweden; Paris, France; Copenhagen, Denmark; and Houston, TX*



46 patients

LCCA: 41 cases (89%)

Closure success: 44 patients (96%)

1 patient intraoperative covered stent

1 patient open conversion 2nd POD (pseudoaneurysm)

4 patients (9%): prolonged manual compression

1 non-flow-limiting dissection

Four patients (9%) stroke



Carbon Dioxide Flushing Technique to Prevent Cerebral Arterial Air Embolism and Stroke During TEVAR

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2016, Vol. 23(2) 393–395
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DOI: 10.1177/1526602816633705
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Tilo Kölbel, MD, PhD¹, Fiona Rohlffs, MD¹, Sabine Wipper, MD, PhD¹, Sebastian W. Carpenter, MD¹, Eike Sebastian Debus, MD, PhD¹, and Nikolaos Tsilimparis, MD, PhD¹

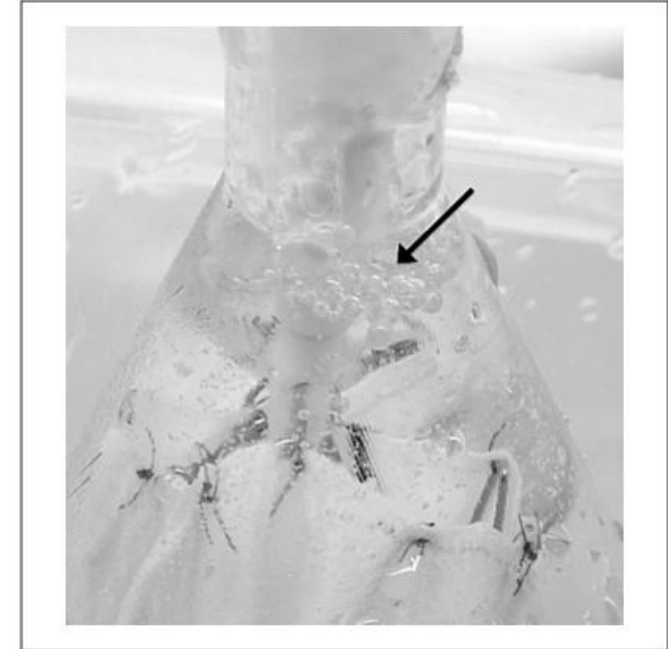


Figure 4. Image of a collection of small bubbles (black arrow). Small bubbles were found at the stent-graft shaft, having been released from small spaces between crimps in the fabric.

Kölbel et al 2016; J Endovasc Surg 23: 393–5
Inci et al. 2016; Sage Open Med 4:1–5
Rohlffs et al. 2017 J EVT 24:84–8

Reduce air burden in graft (flush and CO₂)



Air-Embolism in TEVAR



Mechanisms to reduce gaseous embolization



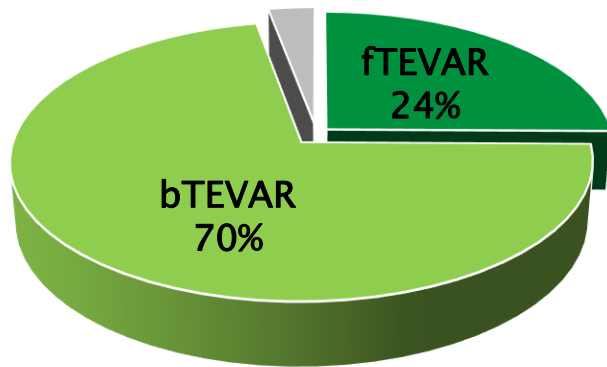
- Flushing with 120ml heparinized saline solution (statt 40 IFU)

Table 1: Gas released after 4 different de-airing scenarios during steps 1 and 2 of Relay Pro NBS stent graft deployment

Test no.	40 ml saline		120 ml saline		CO ₂ de-airing		Ultrasound bath	
	Step 1	Step 2	Step 1	Step 2	Step 1	Step 2	Step 1	Step 2
1	0.530	0.150	0.050	0.075	0.125	0.075	0.075	0.100
2	0.100	0.125	0.025	0.025	0.300	0.075	0.200	0.300
3	0.050	0.075	0.100	0.075	0.200	0.125	0.300	0.125
4	0.025	0.150	0.150	0.125	0.125	0.125	0.200	0.225
5	0.075	0.100	0.150	0.100	0.100	0.150	0.175	0.225
6	0.250	0.175	0.200	0.100	0.175	0.150	0.300	0.175
Median	0.088	0.138	0.125	0.088	0.150	0.125	0.200	0.200
1st quartile	0.056	0.106	0.063	0.075	0.125	0.088	0.181	0.138
3rd quartile	0.213	0.150	0.150	0.100	0.194	0.144	0.275	0.225

How we do it in Munich? LMU Experience Sep. 2018 – Jan. 2026

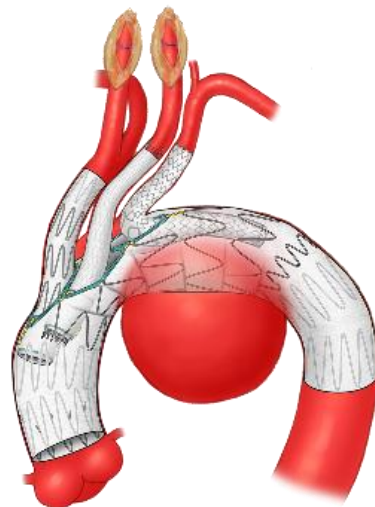
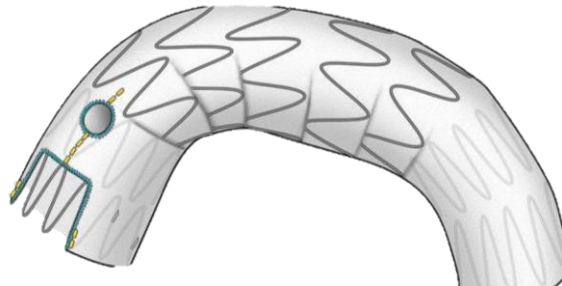
Aortic arch procedures ($n = 140$) PMEG 5%



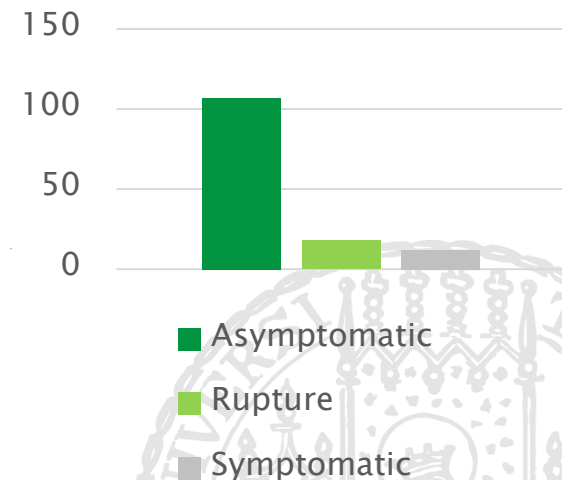
■ fTEVAR ■ bTEVAR ■ PMEG

F/B TEVAR Results ($n=129$)

- Major Stroke: 6.9% (3.7% in elective)
- SCI: 1%



Procedure setting



Urgent 23%
(32/140)

Conclusion



Prevention relies on anticipation !

- Meticulous technique, and minimizing embolic burden at every step!
- Patient selection is critical!

Ultimately, stroke is not a single complication!

...but the result of multiple controllable factors.



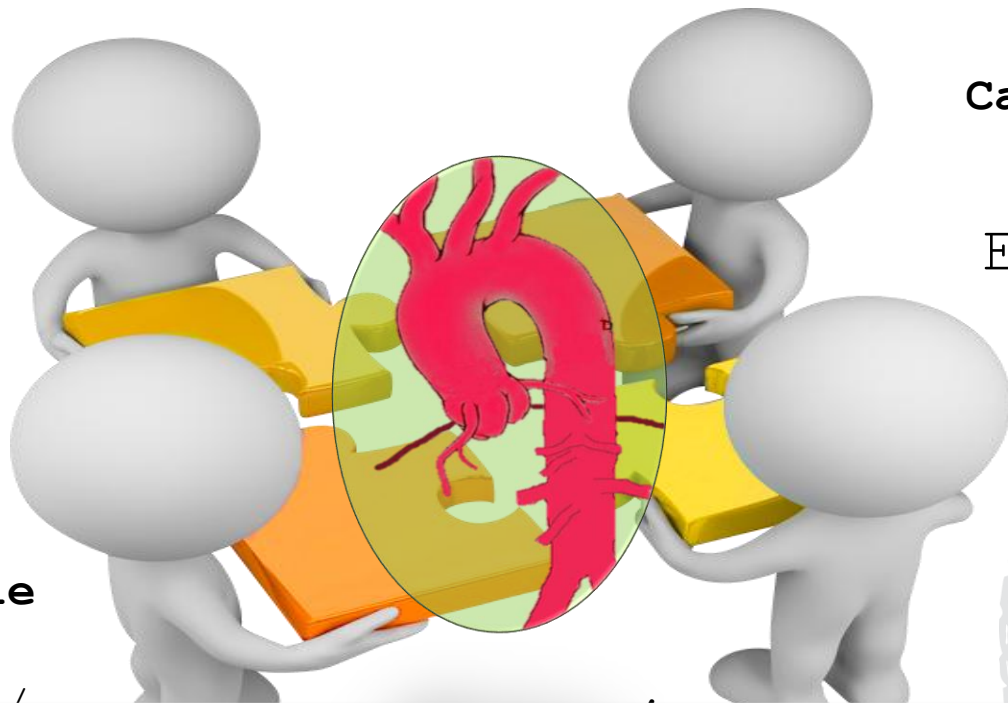
**Vascular and
Endovascular
Surgery**

Pflege

Human genetics

Kinderkardiologie

Anaesthesia /
Intensiv



Cardiac Surgery

Emergency uni

Cardiology

Nephrologi

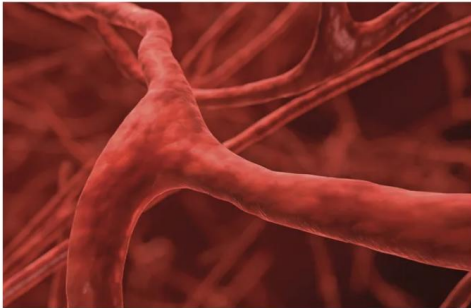
radiology

Every detail counts!

Thank you!

LMU

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5. MÜNCHENER GEFÄSS SYMPOSIUM

19.–20. Juni 2026

Workshops 18. Juni 2026

WISSENSCHAFTLICHE LEITUNG

Univ.-Prof. Dr. med. Nikolaos Tsilimparis
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